Land Use/Transportation Scenario Testing: A Tool for the 1990s

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Abstract

This paper discusses work by the Montgomery County, Maryland, Planning Department to use computerized transport models to examine alternative long-range development scenarios. Some scenarios envision continuing current patterns, policies, and trends, with a mix of automobile-oriented sprawled development and modest clustering around transit nodes, supported by transportation investments favoring roads and relatively weak levels of transportation demand management. Other scenarios examine the potential effects of clustering most new development approvals within walking distance of stations of an expanded rail network, with much greater pedestrian and bicycle friendliness in street and urban design, and significant changes in transportation pricing and employer commuter subsidies to favor alternatives to the automobile.

Various combinations of input assumptions from different forecast years and scenarios are used to help reveal some of the key factors influencing growth of automobile travel --land use patterns, infrastructure investments, transportation pricing, and urban design elements. Holding constant the transportation network while varying land use, and visa versa, provides some indications of the extent to which expanded transportation capacity may increase travel demand and the extent to which growing congestion may reduce demand. The analytic methods used in this research are discussed for their relevance to transportation-air quality conformity analysis and long-range comprehensive planning.

These studies suggest that the pattern of development is more important than the pace or amount of development in determining the level of traffic congestion, energy use, and transport-related air quality. Even if the pace of growth was slowed dramatically, continuing the policies of the mid-1980s would lead to serious traffic congestion. However, alternative scenarios could accommodate doubling the amount of housing and employment with only modest growth in vehicle-miles of travel (VMT), producing acceptable levels of traffic congestion.

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INTRODUCTION

The Need to Evaluate Alternative Policies. Over the past 40 years, transportation and land development policies in the United States have mostly favored automobile-oriented, low-density, suburban sprawled development, rather than the mixed-use, pedestrian and bicycle friendly development patterns clustered around public transport nodes which are common in Europe and Japan. While U.S. transportation and land use policy laid the foundation for several decades of robust economic growth after World War II, there is a growing recognition that these policies are in need of reform to ensure future economic growth and environmental sustainability. Growing traffic congestion, air pollution, energy use, global warming, and foreign debt acquired in part to pay for American imports of petroleum and automobiles have made transportation and land use policy a matter of national strategic interest. Analysis of alternative transport/land use scenarios, including alternative pricing and policies is thus becoming more important to many local and regional decision-makers.

Impetus of New Legislation and Infrastructure Financing Problems. New U.S. federal legislation -- the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the 1990 Clean Air Act Amendments (CAA) -- has laid a foundation for transportation and land use policy reform at the state and local level. Federal transportation funding has shifted towards modal flexibility at the same time that air quality and other problems require a rethinking of transportation investment policy and management systems. In many cities across the U.S., the testing of alternative scenarios and policies will become vital in considering trade-offs that must be made to meet CAA standards. More rigorous and policy-sensitive modeling frameworks will be needed for this scenario testing, including important factors that influence travel demand but which are not accounted for in the current generation of transportation planning models. Many U.S. cities will likely respecify their transportation models in the next several years to respond to these needs.[1]

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[1] Harvey, Greig and Elizabeth Deakin, "Toward Improved Regional Transportation Modeling

This new federal legislation, in combination with fiscal problems at all levels of government, also requires renewed attention to transportation infrastructure financing. ISTEA requires states and regions to identify revenue sources for all major planned facilities, while easing previous restrictions on toll financing and road pricing.

Already, infrastructure financing problems are forcing many U.S. jurisdictions to turn more towards development taxes and impact fees to raise revenues for transportation facility development. With this direction, questions arise about the extent to which the need for new infrastructure is driven by new development vs. changing travel behavior of existing residents vs. transportation and land use policies themselves. Such questions, however, can only be properly answered with models sensitive to various assumptions regarding future development patterns, transportation investments, and travel demand management policies, including pricing, which have a strong effect on the type and level of investment needed. Evaluation of alternative scenarios at a local, regional, and national level will be vital to evaluating difficult trade-offs.

Practice," prepared for National Association of Regional Councils, Washington, DC, 1992; and Replogle, Michael, "Best Practices in Transportation Modeling for Air Quality Planning," Environmental Defense Fund, Boulder, CO, 1991.

Enhancing the Models. The state-of-the-practice in analysis of impact fees, planning issues, and transportation/air quality relationships is currently inadequate to evaluate these factors. The use of fixed trip generation rates and land use forecasts, and models which are insensitive to urban design factors, travel demand management strategies, and parking pricing is widespread. A wide range of factors which affect long-term infrastructure needs and costs, which are subject to influence by governments and the private sector are often neglected evaluation of alternatives.[2]

Relatively simple methods can be used to address these shortcomings in the short-term, while data collection and analysis is underway to lay a foundation for improved models. In the long run, there is promise for the eventual development of long-term least-cost transportation/land use evaluation systems, using enhanced models with alternative scenario generators running on faster computers. These might enable infrastructure financing systems to send more appropriate pricing signals to land developers and travelers and suggest ways of reducing the long-term cost of providing efficient and cost-effective accessibility while meeting clean air standards in our communities.

Growing Use of Alternative Scenario Evaluation. A growing number of communities in North America are advancing this work by undertaking long-range strategic planning studies, often combined with public participation processes intended to develop alternative visions for future transportation systems and land use growth patterns. Such studies and processes have recently been undertaken in Montgomery County, Maryland; Portland, Oregon; Middlesex/ Somerset/Mercer Counties, New Jersey; Seattle, Washington; Victoria, British Columbia; and Toronto, Ontario, to name just a few. The factors leading to these planning efforts vary from region to region, but include many of those discussed above: concerns over the cost and financing of long-term infrastructure needs, the growing severity of traffic congestion, the challenge of meeting tougher air quality standards, and the challenge of making communities more environmentally and economically sustainable.

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2 Michael Replogle, Best Practices in Transportation Modeling for Air Quality Planning, Environmental Defense Fund, Boulder, Colorado, November 1991.

This paper discusses the experience of Montgomery County, Maryland, in assessing alternative future scenarios. The County Planning Department has developed refined transportation modeling systems to evaluate alternative scenarios and strategies in master planning and growth management administration. Key among the model refinements made for the scenario testing reported here was the incorporation of pedestrian friendliness indicators as factors in mode choice modeling, initially using a simple qualitative rating system.[3]

MONTGOMERY COUNTY CONTEXT

Montgomery County, Maryland is a jurisdiction of with a population of about 760,000 people and over 450,000 jobs, immediately north of Washington, DC. Since the 1960s, it has grown rapidly from a mostly rural area with suburban bedroom communities into an increasingly urbanized County with extensive sprawling suburbs, several compact inner ring satellite cities, and several major automobile-dominated "edge cities." High technology, bio-technology, and government-related industry have been the foundation for growth. Major recent infrastructure investments, including a 12-lane expressway and two Metro lines running through the heart of the County, have provided a foundation for substantial long-term economic growth. Growth and traffic have been key political issues over the past two decades, leading the County to adopt an Adequate Public Facilities Ordinance in the 1970s and to develop advanced computer transportation modeling systems for planning and analysis in the 1980s.

Infrastructure financing and the costs of growth have been increasing concerns, as the public has reacted negatively to rising real estate tax burdens which have been driven, in part, by the costs of schools and transportation, especially new roads. The recent recession has intensified these problems. Increasing traffic congestion in the 1980s, driven by both growth and socio-economic changes, has brought into question the ability of long-term master planned infrastructure to meet mobility needs of planned growth.[4] Increased incomes and population growth, a drop in average household size, increased female labor force participation, and substantial employment growth in areas dependent on the automobile for access, combined to spur even greater growth in the number of automobiles and the amount of their use. In response, the County has sought to better understand these relationships and to make appropriate modifications to its long-range plan elements.

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3 Michael Replogle, "Computer Transportation Models for Land Use Regulation and Master Planning in Montgomery County, Maryland," Transportation Research Record 1262, Transportation Research Board, Washington, DC, 1991.

4 Maryland-National Capital Park and Planning Commission, General Plan Assessment, Silver Spring, MD, 1987.

ALTERNATIVE SCENARIO DEVELOPMENT

In this context, Montgomery County undertook the Comprehensive Growth Policy Study,[5] which looked thirty years into the future at the choices the County might face in balancing job and housing growth with attendant demands for transportation and schools, focusing especially on fiscal and traffic congestion impacts. The study developed and evaluated land use and mobility patterns with appropriate bundles of supporting public policies consistent with each scenario. The scenarios were developed on the basis of a number of different vision statements representing various perspectives within the County and built on the work of an 18-month long "Commission on the Future of Montgomery County," which had involved significant public outreach and input.[6]

Four major land use scenarios were devised with different levels of housing and jobs --

1. FAST but balanced growth: 900,000 jobs and 600,000 households County-wide, yielding jobs/housing ratio (J/H) of 1.5.
2. SLOW but balanced growth: 600,000 jobs and 400,000 households, yielding J/H ratio of 1.5.
3. JOBS favoring employment growth: 900,000 jobs and 450,000 households, yielding J/H ratio of 2.0.
4. HOUSING favoring housing growth: 750,000 jobs and 600,000 households, yielding J/H ratio of 1.25.

These were tested against several mobility patterns --

5. AUTO continuing current policies and building out the Master Plan of Highways.
6. VAN adding to this a network of High Occupancy Vehicle lanes.
7. RAIL adding to AUTO a 65-mile light rail network in Montgomery County, connected to a circumferential light rail system paralleling the Capitol Beltway.

The VAN scenario was tested with two variants. One assumed no added bus services over the AUTO scenario. The other introduced a number of frequent express bus services on the HOV network, with feeder bus lines.

Each scenario was crafted to involve a bundle of internally-consistent supportive policy elements, with assumptions concerning --

8. Land Use Pattern. The number of jobs and houses, the ratio between them, and the degree to which they are clustered around transit nodes or dispersed in a sprawled pattern.

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5 Maryland-National Capital Park and Planning Commission, Montgomery County Comprehensive Growth Policy Study, Silver Spring, MD, 1989.

6 Montgomery County Commission on the Future, Envisioning Our Future, Rockville, MD, 1987.

9. Transport Infrastructure. The relative level of transportation investment in roads and public transportation.
10. Pricing and Urban Design. Transportation incentives and enhancements, including both pricing changes in transportation modes and urban design factors, such as the quality of the pedestrian and bicycle environment, proximity of jobs and housing to transit by foot, and the degree of homogeneity/heterogeneity of land uses at a neighborhood level.

These three primary building blocks were varied between scenarios, to provide some sensitivity testing of alternative combinations of assumptions.

The 2020 horizon year was chosen to provide the opportunity for significant alterations in the land use pattern, while assuming no reallocation in existing and already approved development. The forecast level of growth to 2010, particularly for County employment, is not greatly in excess of the amount of already approved development. Given the relatively sprawled pattern of this approved, but not yet built development, there is only modest opportunity to reallocate the forecast growth pattern if one assumes no reallocation of the existing or already approved development.

For the AUTO pattern scenarios, the distribution of housing and employment was based on current zoning. For RAIL pattern scenarios, most new housing and job growth above current levels of approved development were clustered at higher densities near rail stations. The VAN pattern scenarios, combined the clustered employment pattern developed for the RAIL scenarios with the more sprawled housing of the AUTO pattern.

In addition, the RAIL scenario included strong transportation incentives and enhancements (TIE) favoring alternative modes to the automobile, assuming:

- Pedestrian and Bicycle Friendliness. Major investments would be made to make all major activity centers very pedestrian and bicycle friendly, with measures taken to slow and calm automobile traffic in these centers,
- Transit Serviceable Site Planning. Transit serviceable site planning would be adopted County-wide, with less reliance on sprawled campus-style office development and greater mixed-use infill development,
- Parking Pricing and Supply. Parking charges would be much higher than today in all employment areas and parking supply would be capped in central business districts, increasing automobile driver egress time from parking to final destinations slightly,
- Equalization of Commuter Subsidies. An ordinance would be passed to require equalization of commuter subsidies, reducing user perceived public transport fares by half,
- Automobile Use Costs. Gasoline taxes and registration fees or road pricing would effectively double the cost of automobile operation.

The VAN scenario assumed a more modest package of supportive public policies, emphasizing high parking costs for single-occupant automobile commuters with free parking for high-occupancy vehicles.

The VAN scenario also assumed improvements in transit access, pedestrian, and bicycle conditions half way between the AUTO and RAIL scenario levels.

RESULTS OF SCENARIO TESTING

As Figures 1 and 2 [not available] show, the scenarios produced widely different mode share forecasts for AM peak hour work trips. The automobile driver mode share stayed about the same in the AUTO scenarios as it is today, at about 75 percent for all Montgomery County residents, thanks to the assumed growth in transit services proportional to housing and employment growth and a continuation of current pricing and urban design practices. In the VAN scenario relying on carpooling, average auto occupancy increased from 1.15 to 1.30, and the auto driver share fell to 60 percent. In the RAIL scenarios, the use of walk-connected transit increased markedly and the auto driver mode share fell in the range of 45 to 55 percent.

- Work trip mode share resulting from different CGPS scenarios
- AM peak hour traffic congestion and automobile driver mode shares.

Figure 2 [not available] illustrates the average level of traffic congestion simulated for AM peak hour trips under a number of different CGPS scenarios, together with the mode share for auto driver work trips for County residents. Level of service has been measured for each scenario as the VMT (vehicle-miles-traveled)-weighted average volume-to-capacity (V/C) on all roadway links in the County.

Only the RAIL scenarios produced levels of traffic congestion within the County's level of service standards under the Adequate Public Facilities Ordinance. The VAN scenarios came close, but still somewhat short of acceptability, unless strong transportation demand management measures, like those in the RAIL strategy, were used, along with very high frequency bus services on the HOV system. The AUTO pattern showed unacceptably high levels of traffic congestion, even when job and housing growth rates in the County were reduced substantially below the rates of recent decades in the SLOW Balanced Growth scenario.

With all else held constant in the RAIL FAST scenario, but more housing clustered in the inner ring and core of the region along the Metro lines, in a RAIL FAST scenario variant called Recentralization, traffic congestion levels in Montgomery County fell significantly. This scenario was estimated to be the best performer for traffic congestion levels and mode shares. However, it would require major housing reinvestment in decaying urban areas with poor schools and crime problems which have recently been losing, not gaining, population. It would require restraining development in metropolitan fringe areas recently undergoing substantial growth. However, this scenario points up the major gains in efficiency of infrastructure utilization that can be achieved by containing sprawl and channeling reinvestment in housing to near-central city and inner ring satellite city areas.

A number of conclusions can be drawn from the Comprehensive Growth Policy Study and its evaluation of alternative scenarios. Some of the key ideas emerging from the study are discussed below.

11. If the County were to continue to rely on the automobile as the predominant means for future mobility around and to permit growth in sprawled development patterns within its growth corridors, this growth would likely lead to unacceptable levels of traffic congestion even with the assumed $3.5 billion completion of master planned highways and with the expansion of public transportation in proportion to housing and employment growth. Even tight restraint of growth and development in the County would not be sufficient to alter this likely outcome, due to growth in traffic from surrounding jurisdictions. Slowing growth would likely make it harder to pay for needed infrastructure and potentially exacerbate housing affordability problems.
12. A viable strategy for long-term sustainable growth within the County without unacceptable levels of traffic congestion could be based on developing more compact and mixed land use patterns and transportation systems that will encourage more travel by walking, bicycling, public transportation, and carpooling. By clustering most new development near an expanded rail and busway system, improving pedestrian and bicycle conditions, and equalizing commuter subsidies, the County could potentially accommodate a doubling of households and employment over 30 years with acceptable traffic congestion. This strategy could result in County-wide VMT and traffic congestion levels comparable to those of the current 2010 forecast, while accommodating 62% more houses and 29% more jobs in the County than the 2010 forecast. Significant infrastructure investment, particularly in transit, would be a necessary but not sufficient element in this strategy.
13. To achieve these patterns, down-zoning would be necessary in some areas not well served by public transportation and changes in zoning to permit more mixed land uses at higher densities would be necessary for some areas served by current or future express public transportation services, such as Metro, commuter rail, or light rail. Transferable development rights (TDRs) might be a useful mechanism to implement this, building on the County's successful experience with TDRs for preservation of agricultural land.
14. To achieve these more sustainable development patterns, affordable housing would need to be developed at higher densities in locations near employment and good public transportation, although this goes against what the market is generally now producing. Additional housing in the inner ring suburbs of the Washington region and in the District of Columbia generates far less new traffic congestion than new housing at the edges of the region.
15. To achieve these more sustainable development patterns and ensure efficient use of transportation investments, pedestrians, cyclists, and public transportation would need to be given priority in planning local circulation within and access to designated growth centers. Automobile commuting to these centers would need to be discouraged by high parking charges, limits on growth of parking supply, and equalization of commuter subsidies to ensure that more clustered growth does not threaten existing nearby neighborhoods with excessive traffic.
16. To achieve these more sustainable development patterns and maximize opportunities for transit use, the County would need to connect all major existing growth centers together by high quality public transportation, such as the new $2 billion, 65-mile light rail network evaluated as part of the CGPS. This system could complement increased services and new stations on the Metro and commuter rail systems and include development of a Washington metropolitan circumferential light rail or busway system to help alleviate traffic problems on the Capital Beltway.

17. To enhance mobility for the existing low-density residential areas not well served by transit and to increase the efficiency of the road system, the County could explore opportunities for High Occupancy Vehicle (HOV) lanes, especially in radial corridors. Reallocating lanes to HOV on the newly widened 12-lane I-270 freeway, for example, might provide added short-term growth capacity in advance of light rail development. These facilities could play an important role as busways.
18. Four to six billion dollars in transportation capital improvements in Montgomery County will likely be needed over the next three decades to avoid sharp increases in traffic congestion. Financing these improvements will require substantial aid from the Federal and State governments and development of new or expanded revenue sources, such as increased gasoline taxes, higher automobile registration fees, an excise tax on automobile parking spaces, and the introduction of toll roads and central area pricing.
19. A shortage of affordable housing near jobs in Montgomery County is one of the factors contributing to traffic congestion problems. Faster solutions would likely require much larger funding than solutions that restructure real estate value capture over a longer period of time. Promising avenues worthy of investigation as lesser cost solutions may include land banking tied to the development of limited equity housing cooperatives, regulatory linkage of commercial and housing development approvals, and encouragement of accessory apartments to increase density in neighborhoods, especially where good transit services are available.

The CGPS showed that changing the pattern of land use and urban design and the price of transportation could have a major effect on the vehicle miles of travel in Montgomery County. Even if growth in the County was slowed dramatically over the next 30 years, there would likely be substantial increases in traffic congestion due to growth in traffic from outside the County. The level of traffic congestion in the County is very sensitive to where new housing growth occurs in the region outside the County. Traffic congestion and needs for transportation system expansion are greater if more workers come each morning from the County's northern neighboring counties, and far less if there is expanded investment in housing inside the Beltway near Metro stations. The location of a larger share of employment in the less urbanized northern part of the County likely encourages faster growth in automobile-oriented exurban residential development.

The non-automobile driver mode share and the ratio between peak hour VMT on County roads and the number of County households were both reduced significantly when growth was clustered near transit rather than allocated in the more sprawled current forecast pattern. However, expansion of the transitway network was required to serve many existing growth centers not now well served by transit and to provide an acceptable mix of sites for infill development within the growth corridors. Moreover, clustering was found to result in unacceptable local traffic congestion unless changes were made in transportation pricing and urban design, including better provisions for pedestrians and bicyclists.

While the CGPS evaluated widely varying scenarios of land use, infrastructure, pricing, and policy, it used the same master plan of highways network for all scenarios and did not seek to produce an equivalent congestion level between different land use/pricing/policy scenarios. A true comparison of scenarios for cost allocation and attribution would require adjustment of the level of infrastructure investment for each scenario to produce an equivalent composite level of service. For example, each scenario might be refined to meet the standards of the County's Annual Growth Policy. (This policy regulates new development in the County, and permits more traffic congestion in areas where the level of service for transit and alternatives to the automobile is higher.) This would require adding or deleting infrastructure in a number of land use/pricing/policy scenarios to produce an equivalent minimally-acceptable level of traffic congestion, and only then estimating the cost of the infrastructure and transportation services for that scenario in relation to the other scenarios. However, this study did not provide the opportunity for such analysis.

The CGPS succeeded in giving significant direction to the development of revised subarea master plans, County-wide growth management, and an ongoing update of the County Master Plan of Transportation, although there is continued debate over the extent to which many concepts should be pursued. As the County faces a growing fiscal crisis, traffic and housing affordability problems, and challenges in meeting environmental requirements, the CGPS continues to suggest ways of making growth both economically and environmentally sustainable.

COMPARISON WITH 1990 AND 2010 FORECAST VMT

Several additional combinations of land use, transportation investment, and transportation policies were tested to give an indication of the relative contribution of different factors to growth in vehicle miles of travel. These included:

1990 Base Case:
- 1990 transportation networks
- 1990 land use with 1990 demographics
- Current transportation pricing/policies

2010 Reference Scenario:
- 2010 transportation networks
- 2010 land use with 2010 demographics
- Current transportation pricing/policies

Test One: 2010 Transportation Investment with 1990 Land Use:
- 2010 transportation networks
- 1990 land use with 2010 demographics
- Current transportation pricing/policies

Test Two: 1990 Transportation Investment with 2010 Land Use
- 1990 transportation networks
- 2010 land use with 2010 demographics
- Current transportation pricing/policies

Taken together with the CGPS, these scenarios provide a basis for analysis how County-wide total VMT changes in response to various factors. Table 1 shows a number of key aggregate inputs and outputs for Montgomery County under these various combinations of factors. AM Peak hour simulated VMT on Montgomery County roads varies in these scenarios from 1.13 million in the 1987 base to 2.91 million in the AUTO-Fast-NoTIE scenario, with a forecast of 1.81 million for the 2010 Reference Scenario.

Comparing the 1990 Conditions to the 2010 Reference Scenario shows that AM peak hour VMT was forecast to rise by 36% in response to the forecast 33% growth in County households and 54% growth in County employment. As lane-miles of road capacity increase by 20% between these scenarios, it appears that the 2010 pattern produces more effective utilization of available road capacity than in 1990, with less directionality in AM peak hour link flows. The average AM peak hour VMT-weighted level of traffic congestion County-wide was estimated to increase by only 1% for freeways and by 3% on local roads. However, freeways are currently estimated to be 9% more congested than local roads and the largest share of forecast travel growth is estimated to occur on freeways. Average AM peak hour travel speeds for County residents are estimated to fall by one-fifth, as average travel time increases from 27 to 33 minutes while average trip length drops from 10.5 miles to 10.1 miles.[7]

The 2010 Transportation Investment with 1990 Land Use scenario was designed to show the effect of freezing development in the County, but making anticipated transportation investments, which would stimulate existing residents to travel farther and faster, while accommodating the growth in traffic from surrounding jurisdictions. Compared with the 1990 Conditions Scenario, this produces 11% more AM peak hour County VMT, operating with 7% less average traffic congestion on a network with 20% more lane miles of capacity. This expanded capacity and job and housing growth outside Montgomery County cause average AM peak hour County resident trip length to increase from 10.5 to 11.15 miles, and marginally increases average trip speed.

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[7] A much richer exploration of the likely changes in travel demand and the functioning of the traffic system between 1990 and 2010 in Montgomery County, Maryland, using a more advanced and newly estimated set of travel demand models and equilibrium feedback of congestion into trip spatial and temporal distribution, can be found in Levinson, David M. and Ajay Kumar, "Integrating Feedback into the Transportation Planning Model: Structure and Application," presented to the Metropolitan Washington Council of Governments Travel Forecasting Subcommittee, March 11, 1992 (M-NCPPC, 8787 Georgia Ave., Silver Spring, MD 20910).

The 1990 Transportation Investment with 2010 Land Use scenario shows the effect of halting investment in new transportation infrastructure but permitting continued forecast growth patterns. It shows the extent to which people might be expected to change their behavior if faced with rising traffic congestion levels. Comparing this scenario to the 2010 Reference Scenario shows the extent to which planned infrastructure investment might alleviate traffic congestion, while stimulating VMT. Compared with the 2010 Reference Scenario, this produces 13% fewer AM peak hour County VMT, operating with 7% higher traffic congestion on County highways. This congestion was estimated to reduce average trip speed by 4% and to reduce average trip length by 7% to 9.48 miles, while slightly reducing average trip time for AM peak hour trips made by County residents. In other words, expanding lane-miles of capacity in Montgomery County by 20% between 1990 and 2010 would tend to produce almost 15% more AM peak hour VMT on County roads than would occur if capacity were held constant and congestion effects were permitted to discourage travel demand.

The AUTO scenarios in the CGPS all produced significant growth in VMT over the 2010 Reference Scenario. The AUTO-Trend-NoTIE Scenario represented a continuation of 1989 zoning, forecasts, and policies. When compared to the 2010 Reference Scenario, this included a 21% growth in households, a 7% increase in jobs, and a 34% growth in both lane-miles of road capacity and AM peak hour rail seat-miles of capacity, producing a 27% increase in VMT and significant worsening of average traffic congestion levels. Even with slower growth, as in the AUTO-Slow-NoTIE Scenario, traffic congestion levels were estimated to remain unacceptable, and AM peak hour VMT per household was significantly higher than today's levels.

Figure 3 [not available] shows the total VMT on Montgomery County roads divided by the number of jobs and households in Montgomery County. It should be noted that the data given is not the simulated AM peak hour VMT generated per Montgomery County household or job, which would likely show somewhat less variation than the latter measure, which is influenced by through traffic generated in other jurisdictions.

Only the introduction of strong transportation incentives and enhancements (TIE) --involving pricing and urban design changes favoring pedestrian and bicycle traffic -- could hold AUTO scenario VMT per household to 1987 levels.

The Recentralization strategy shifted much of the non-Montgomery County housing growth assumed for the extreme outer ring exurban area (which was represented as external stations in the model) to non-Montgomery County locations near Metro stations inside the Capital Beltway, in the District of Columbia and Prince George's County, closer to the primary regional employment core. This urban revitalization strategy reduced Montgomery County VMT by 7% from the RAIL-Fast-StrongTIE Scenario while holding constant both land use and transportation within the County.

AM peak hour VMT per household increase from 4.40 in 1987 to 4.88 in the 2010 Reference Scenario, 5.09 in the AUTO-Trend-NoTIE Scenario, and 5.29 in the 1990 Transportation Investment with 2010 Land Use, indicating the sensitivity of this value to changes in road capacity and household growth. Strong TIE measures have a major influence on VMT per household. When applied in

AUTO-Trend Scenarios, Strong TIE causes VMT per household to drop by 14%. Strong TIE measures play a major role in reducing VMT per household in the RAIL scenarios below 1990 levels. Substituting current policies for the otherwise assumed Strong TIE in the RAIL-Fast Scenarios causes VMT per household to increase from 3.27 to 3.83, a jump of 17%. Clustering more non-Montgomery County regional housing growth inside the Beltway near Metro stations in RAIL-Fast-StrongTIE-Recentralized, the County total simulated AM peak hour VMT per County household falls to 3.03, some 36% less than simulated for 1990. This produces among the lowest County traffic congestion level of any CGPS scenario, although it doubled the number of jobs and households in the County from 1990 levels.

The only scenario producing lower VMT was the RAIL-Housing-StrongTIE scenario, which assumed a job/housing ratio of 1.25, which would be a dramatic reversal of the historical market trend in the County towards a higher job/housing ratio as urbanization has proceeded. This scenario was estimated to yield VMT about the same as 1990 conditions, but with an average congestion level comparable to the RAIL-Fast-StrongTIE scenario. This higher congestion level despite lower VMT is likely due to significant differences in the effectiveness of utilization of assumed highway network capacity. With a job/housing ratio below the ratio of resident workers/household, the County would need to once again shift to exporting workers each morning to other jurisdictions in the region, increasing the directional imbalance of traffic flows on the network. Much of the highway capacity increase assumed in the Master Plan of Highways used for all of these scenarios was oriented to serving major County employment growth, rather than the needs that would be exhibited in the RAIL-Housing-StrongTIE scenario.

Figure 3 [not available] illustrates that AM peak hour Montgomery County VMT per Montgomery County job shows similar variations between scenarios. Moreover, it illustrates that the amount of traffic in the County is only partly a function of the amount of housing and employment. The pattern of development, the balance between housing and employment, the provision of transportation infrastructure, and the transportation pricing and urban design policies adopted by the County all have a highly significant influence on traffic levels.

With the same 600,000 households and 900,000 jobs in Montgomery County, the AUTO-NoTIE scenario produces 2.91 million AM peak hour VMT on County road, while the RAIL-TIE scenarios produce 1.82-1.96 million VMT, and the RAIL-NoTIE scenario produces 2.30 million VMT. The more compact and transit dependent RAIL-TIE scenarios would also produce far fewer automobile trips and enable more households to live comfortably with somewhat fewer automobiles than are required for effective mobility today.

RELEVANCE TO TRANSPORTATION-AIR QUALITY ANALYSIS

The experience of Montgomery County, Maryland, in evaluating alternative scenarios may be helpful to planners evaluating transportation-related air pollution emission reduction strategies. This experience shows the potential sensitivity of key factors related to air pollution emissions -- VMT, travel speed, and mode choice -- to alternative assumptions in the modeling process. The initial round of transportation-air quality conformity analysis has not provided a rigorous examination of many important factors and policy choices. However, future conformity analysis in many regions will likely move to a broader framework in which these factors might be examined, as in Montgomery County.

The initial round of transportation-air quality conformity analysis performed under the Clean Air Act focused on comparing build/no-build scenarios with identical land use forecasts. These analyses have asserted that by building more road capacity, average travel speeds would increase very slightly. They have then focused solely on running emissions of automobiles, and assumed that emission rates are reduced by increased travel speeds. On that basis, these analyses have in many cases concluded that a build scenario will reduce CO and ROG emissions, usually by a minuscule amount that is far less than the accuracy of the models used to simulate the transportation, land use, pricing, and air quality systems.

However, several factors make these findings suspect. As this study has shown, expansion of road capacity can have a significant effect on VMT growth, as congestion feeds back to influence travel demand. However, most regional transportation models used for conformity analysis are not structured to properly and fully account for the effects of peak period congestion on temporal and spatial trip distribution and speeds. Moreover, most models have assumed that the provision or deletion of planned transportation capacity will have no effect on land use development patterns or timing. Thus, many conformity analyses may have underestimated the VMT-suppression and overestimated the speed reductions that would likely occur under a no-build scenario, while underestimating the VMT-growth and overestimating the speed improvements that would likely occur under a build scenario.

In addition, most of the travel models used for these analyses fail to simulate highway travel that occurs at speeds above 55 mph, which produce higher emissions at higher speeds. Expansion of freeways generally increase the amount of travel at speeds above 55 mph.

The assumption of higher speeds reducing emissions is also challenged by recent research that has better accounted for typical driving conditions. As Harvey and Deakin note:[8]

> "Of even greater significance are recent findings on the relative contribution to running emissions made by extreme accelerations, which remain difficult to control even with the most sophisticated catalytic converter technology. New measurements indicate the CO and ROG emissions from newer vehicles actually increase in the range of 25 to 40 mph, then decrease between 40 and 55 before increasing again.
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> Taken together, these developments imply that running emissions benefits from speed improvements for a constant volume of traffic are no longer an automatic outcome. Considering that running emissions are less than half of all mobile source emissions (the rest

8 Harvey, Greig and Elizabeth Deakin, "Toward Improved Regional Transportation Modeling Practice," prepared for National Association of Regional Councils, Washington, DC, 1992, p.22.

> are from trips starts and evaporation), the implications for transportation-air quality analysis are obvious and potentially quite serious."

A major implication of this is that the models being used today for transportation-air quality conformity -- which are sensitive only to changes in running emissions -- are inadequate tools for the task.[9] New analysis frameworks are needed, which separately consider VMT-related running emissions, trip-related cold-start and hot-soak emissions, and vehicle-ownership-related evaporative emissions, using enhanced models. Within this larger framework, it is logical for communities to explore transportation, land use, pricing, and policy alternatives in a quest for lower-cost, more effective strategies.

CONCLUSION

The development and testing of alternative transportation, land use, pricing, and policy scenarios can illuminate policy choices and tough trade-offs which will be faced by many metropolitan regions in the 1990s.

As this paper has illustrated, VMT and mode share (which affects the number of vehicle trip starts) can be significantly influenced by changes in transportation incentives and enhancements, urban design, and other factors influencing travel demand, given the same land use pattern. VMT and mode share can be further influenced by changes in land use patterns consistent with different transportation investments, such as more clustered development within walking distance of high quality public transportation. Together, all these elements can influence the level of automobile ownership and use, the amount and type of investment needed for new infrastructure, and economic competitiveness, as well as environmental quality.

Further research and development is needed to enhance regional transportation, land use, pricing, and air quality modeling of alternative scenarios. Fiscally-pressed state and local governments need to explore how such analytic systems can reduce the long-terms costs of meeting environmental, economic, and community goals. The potential savings from identification and implementation of alternative strategies likely outweigh the costs of developing better information and analysis systems by several orders of magnitude.

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9 Michael Replogle, Best Practices in Transportation Modeling for Air Quality Planning, Environmental Defense Fund, Boulder, Colorado, November 1991.

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